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An Innovative Near-Peer Mentoring Model for Undergraduate and Secondary Students: STEM Focus

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Abstract This study examined a novel mentoring model, *near-peer mentorship*, that supports the development of mentee and mentor, incorporates established principles of mentoring, and offers unique opportunities to integrate research and teaching in a science, technology, engineering, and mathematics (STEM) internship. Using qualitative methods, this model was examined from the perspectives of near-peer mentors and student mentees during a science education internship at the Walter Reed Army Institute of Research. Results revealed

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14. ABSTRACT
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Keywords mentoring · STEM · educational models · undergraduate internship · undergraduate research

Mentorship has long been established as a successful educational model to encourage the development of early career scientists (Barondess, 1995; Loue, 2011; Thiry, Laursen, & Hunter, 2011). In this article we explain a new form of mentorship that affords significant benefits for both the mentee and mentor; incorporates established principles of mentoring; and offers novel opportunities for integrating research and teaching in the science, technology, engineering, and mathematical (STEM) disciplines. This innovative approach is termed *near-peer mentorship*. Our study analyzed the benefits and challenges associated with this model as reported by near-peer mentors and student mentees.

The Model

The near-peer mentorship model was first implemented at the Walter Reed Army Institute of Research (WRAIR) (Jett, Anderson, & Yourick, 2005) and has since been adopted by 10 other United States Army research centers and one Navy research center. A *near-peer mentor* is defined as an undergraduate or post-baccalaureate student who completes a summer teaching internship in addition to a research internship. The research internship is completed at the WRAIR or a university laboratory during the academic year. During the summer, the undergraduate or post-baccalaureate students apply to participate in the WRAIR teaching laboratory. As near-peer mentors the college level students are instructors in the “Gains in the Education of Mathematics and Science” (GEMS) program for middle and high school students. The GEMS program is part of a continuum of science education outreach programs hosted by the WRAIR.

The continuum of WRAIR outreach programs begins with the multileveled summer GEMS program (grades 5-12, one week). As the GEMS students mature, they can transition into an advanced program (grades 11-12, 10 weeks) that places them in a WRAIR research laboratory. Undergraduates who major in the STEM disciplines can apply to the WRAIR College Qualified Leaders program. This college program provides internships ranging from 12 weeks to 3 years, and it has two related paths for academically qualified students. They can apply for a research internship in a specific field, or they can apply for a near-peer mentorship in the teaching laboratory. The two paths are not mutually exclusive. Internal documents at the WRAIR indicate that approximately 55% of the near-peer mentors have completed a previous WRAIR internship. As a final point, the internship continuum can be entered at any level. Students from middle school to post-baccalaureate studies can apply for an internship without previous participation in an earlier program. However, each level is designed to build upon previous experiences and prepares the student for the next stage.

As near-peer mentors, the college level students act as GEMS lab instructors, subject matter experts, role models for academic success, curriculum designers, lab safety officers, technicians in WRAIR research labs; and some have authored both educational and research publications (e.g., Hammamieh et al., 2005). The mentors introduce inquiry-based STEM modules to the GEMS students, offer educational and career guidance, build supportive relationships with their mentees, and encourage students to pursue their goals. Prior to teaching

they receive two-weeks of pedagogical training from a secondary STEM instructor and a medical educator.

The near-peer mentorship model and the more familiar undergraduate research model share an emphasis on scientific learning, preparation for STEM careers, and professional growth and development (Adedokun et al., 2012; Landrum & Nelson, 2002; Thomas & Gillespie, 2008; Thurgood, Ordowich, & Brown, 2010). While there is a wealth of literature reviewing mentorship in science education (Allen, Eby, O'Brien, Lentz, 2008; Loue, 2011), near-peer mentorship is an interdisciplinary approach that incorporates the strengths of established STEM mentorship models (Terrion & Leonard, 2007) and enhances the learning experience of all participants. One distinction from the traditional model is that, while undergraduate near-peer mentors are instructed by experienced scientists rather than being instructed in a specific protocol, their instruction is dedicated to developing investigations for the GEMS students. The near-peer mentors then apply their new knowledge and abilities in the teaching laboratory by mentoring the younger students. The classical undergraduate research experience model typically involves only one mentoring relationship, with the undergraduate as the mentee and the expert as mentor (Dolan & Johnson, 2009; Russell, Hancock, & McCullough, 2007). In this model, the undergraduate typically gains laboratory experience but limited or no teaching experience (Landrum & Nelson, 2002). The near-peer mentorship model diverges from the traditional model by equally emphasizing the undergraduate's ability to share knowledge with their ability to acquire knowledge.

The second distinguishing factor of this model is that the participants are not selected from highly-benefited populations, but rather from less-benefited populations (Chemers, Zurbriggen, Syed, Goza, & Bearman, 2011). The near-peer mentors and the GEMS students they instruct are from urban community and schools with limited resources. Participant selection is based on interest, enthusiasm, willingness to learn, zip codes throughout the metropolitan area, and a brief essay. As a result, more than 50% of WRAIR-GEMS students and their near-peer mentors are from populations underrepresented in the STEM disciplines.

A third point of divergence from the typical undergraduate research experience is that the near-peer mentorship model emphasizes the personal growth and development of participants by encouraging them to explore topics of personal interest through research, teaching, and mentorship. The research assistant experience generally offers less opportunity for interns to explore personal interests (Sadler & McKinney, 2010).

While research has documented the positive educational, personal, and professional benefits associated with serving as an undergraduate research assistant (Thurgood, Ordowich, & Brown, 2010), less is known about models incorporating near-peer mentorship. Given the differences between the near-peer mentorship model and established novice and scientist mentoring programs, the near-peer mentor model warrants additional inquiry and exploration to examine outcomes and associated benefits.

The Study

This study explored the experiences of near-peer mentors participating in the 2012 summer program. Near-peer mentors reported on their development as professionals, teachers, and scientists as well as changes in their self-confidence and self-efficacy. High school students were also asked to provide feedback about their leaders as a complement to the near-peer mentor comments. A qualitative approach was used to gain an understanding of near-peer mentor and student perceptions in their own words (Deaton & Deaton, 2012).

Program and Context

During summer GEMS, middle and high school students participate in an inquiry-based laboratory experience for five days at the beginning, intermediate, or advanced level. The GEMS program follows the community of practice model, providing a pathway from science novice on the periphery to an active member of a science-oriented group (Thiry & Laursen, 2011). Near-peer mentors are considered part of the learning continuum. The mentors assume different roles and levels of responsibility depending on their background.

Research scientists, in conjunction with near-peer mentors, design age-appropriate laboratory protocols related to current research. The multi-day investigations require students to gain new skills, collect data, mathematically organize the data, analyze results, and form conclusions. Modules range from 30 minutes to five days in length and involve hands-on learning experiences with no more than 15 minutes of formal lecture. These research-based modules are designed to give students the opportunity to participate in scientific experiments; gain hands-on experience with lab materials, tools, and techniques; explore novel ways of thinking; and make new connections between STEM and their own learning and interests. Each module is delivered by one lead near-peer mentor and one supporting mentor. Those not scheduled as lead or support mentors help students and provide assistance as needed. An educational mentor is on site and conducts daily observations. GEMS students are divided into smaller groups (10 students with two mentors) allowing several modules to be conducted simultaneously as students gather around a single lab table.

Near-peer mentors are responsible for developing an original laboratory protocol, which involves conceptualizing, designing, and implementing an experiment; analyzing the results; and creating a poster for presenting results during closing ceremonies to an audience of peers, guests, and WRAIR scientists. The mentors are given the opportunity to select topics in their areas of interest and receive supervision from lead scientists throughout project development. Examples of near-peer mentor projects during the 2012 GEMS program included using an oscilloscope application on an iPad to record neuronal responses during mechanical stimulation of insect limbs, an assessment of the evolutionary adaptation of *Pseudomonas fluorescens* in response to *Tetrahymena thermophilia* predation, antibiotics from fungi applied to soil bacteria, and exploring sustainable energy.

The 2012 program was conducted in a fully equipped teaching laboratory at the WRAIR. The program had frequent military-affiliated speakers to lead short, informative discussions. During training, mentors were prepared to act as subject matter experts and to provide guidance to students with respect to course selection and educational services. The WRAIR GEMS program has trained 240 undergraduate and graduate students to be near-peer mentors, and they have taught 4,448 students over 11 years.

Participants, Training, and Activities

During the 2012 program, 11 near-peer mentors were selected based on their applications, research background, experience with youth, and interviews. They ranged in age from 18 to 25 ($M = 21$) and were either undergraduate ($n = 7$) or post-baccalaureate ($n = 4$) students living in the National Capitol Region (Washington D.C., Southern Maryland, Northern Virginia, Northern West Virginia). Reflecting the diversity of the area (Hill, Shaw, Taylor, & Hallar, 2011), the six males and five females had African American ($n = 4$), Caucasian ($n = 4$), Asian

Pacific ($n = 1$) and Latino ($n = 2$) heritage. The educational stipend ranged from approximately $5,000 to $8,000 for a 12-week period.

A total of 475 middle and high school students participated in the GEMS program in 2012. The student group was 34% African American, 29% Asian Pacific, 7% Latino, 18% Caucasian, 8% multiracial, and 4% unknown.

Four leaders were continuously involved in the WRAIR GEMS program as mentors, trainers, and supervisors. The neuropharmacologist, educational psychologist, chemist, and physiologist/medical educator, plus guest scientists provided two weeks of training in pedagogy, lesson planning, laboratory protocols, and WRAIR affiliated research. The pedagogical training included the six strands of science learning for informal environments endorsed by the National Research Council (National Research Council, 2009).

Under the supervision of the leaders and volunteer scientists, the mentors created lab investigations that incorporated research, mentor interests, innovative teaching strategies, and elements of the STEM standards used by states in the National Capitol Region. Each mentor was responsible for the development and delivery of a particular module. The leaders approved all modules prior to implementation.

Measures

We used two surveys for this study. A GEMS student survey was administered to advanced students (grades 11 and 12). An open response question asked students to complete the prompt, "the best part of having near-peer mentors was …, because…." Of the 70 students who completed the survey, 59 completed this prompt. No identifying information was gathered during survey administration.

The second survey was designed for the near-peer mentors. The mentor survey contained 20 free-response questions that investigated near-peer mentor perceptions of their participation in the program, peers, STEM learning, teaching skills, and personal and professional development. The questions were developed through a review of previous mentor reflections, observation of the 2012 summer program, and a review of the current literature on measurement of mentorship and internship experiences (e.g., Bulte, Betts, Garner, & Durning, 2007; Sadler & McKinney, 2010;). Surveys were distributed and returned via email to an external evaluator.

Data Analysis

We converted the written survey responses into Word files that were then entered into ATLAS/Ti 7.0, a qualitative data analysis research program (Atlas.ti, Qualitative Data Analysis and Research Program, 2013). Category codes and sub-codes were developed using a deductive-inductive process (Nastasi & Schensul, 2005). Through a literature review, we identified common categories in mentoring studies, which formed the outline of the first coding hierarchy. After independently reading the responses, we identified themes based on the comments as compared to published findings and current learning theories. The iterative process of reviewing the literature and the data continued until 100% consensus was reached for all data sets and definitions.

We report our results in two sections: near-peer mentor survey results and GEMS student survey results. Data analysis revealed that a coding hierarchy that addressed the near-peer mentor experience within the GEMS program contained two primary themes, *growth and maturation* and *perceptions of near-peer mentorship*.

Results

Growth and Maturation

The primary code, *growth and maturation*, described ways in which near-peer mentors reported their development as professionals, teachers, and scientists. The near-peer mentors wrote about learning the skills necessary for professional success. These skills included adaptability to change, professional attire, timeliness, being responsible, workplace performance, and content knowledge. The mentors wrote about meeting professional expectations 53 times. One mentor described dawning professionalism as, “I learned that …accountability is a very important factor because others do count on you to do whatever part you’re assigned to make the program run smoothly.” Respondents frequently mentioned the importance of learning to be adaptable to a fast-paced environment. One commented, “I learned that nothing is set in stone; there is no such thing as being over prepared.” Another said that “things rarely go according to plan. However, that doesn’t mean that you won’t be successful. It just means that you’re going to have to be ready and flexible.” Finally, mentors wrote about increased knowledge with one reflecting that “It forced me to become adaptable and to learn materials much further and deeply to prepare for an assault of questions. That’s what I loved.”

Maturation in oral and written language skills was mentioned seven times by the mentors. One leader stated, “I’m definitely benefitting from improving my ability to communicate concepts to a broader audience than my biologist peers.” Another wrote about the improved ability to convey information in that “I’ve been able to further develop my ability to communicate fairly complex ideas.”

Near-peer mentors wrote about how the internship contributed to career development 21 times. One explained that the experience solidified an interest in education while another said that the GEMS experience had piqued an interest in microbiology. Program involvement helped to develop a new interest in another mentor who wrote, “As I pursue other career goals, I would also like to be connected to science education especially to young women pursuing science.” Linked to career development were fourteen responses that related to enhanced employability. The mentors spoke of gaining authentic experiences before graduate school. One near-peer mentor combined communication skills with career and employability:

> I’ve also been able to further develop my ability to communicate fairly complex ideas with middle and high school students. This skill will definitely be useful in the future, as I will need to communicate my ideas to the broader public.

All of the mentors wrote about how assuming the responsibilities of teaching and mentoring helped them mature. On 20 occasions they wrote of delivering lessons. One shared a single word that influenced his teaching:

> Patience. Sometimes it can be very trying to work with a student who is not cooperative. Most of the time it just takes time and repetition to get them to work with you, but that can be very difficult if the student does not want to participate.

Fourteen of the written comments discussed working with a diverse population of students. One stated, “Each age group needs specific amounts of guidance and supervision. One must be capable and willing to read and adjust to every student’s needs.” Near-peer mentors also described the challenge of working with students of varying ability levels. “It is difficult to find a balance between teaching those that know a lot and those that are very unfamiliar with a topic.” As opposed to challenging students, some respondents wrote of inspiring students:

> One of the defining moments of this program for me was when I met a girl who was diagnosed with a rare disease. Despite her situation, she was optimistic and aspired to go into the field of medicine. Although she was faced with this illness, she was more inspired than other students and displayed a passion for the sciences that you don't see in many students. I was humbled by her drive and optimism.

Eighteen times mentors commented on the challenging but rewarding process of preparing lessons. One respondent said, "Though there was a lot of stress in developing and teaching science modules, watching the kids learn and have fun while doing it was very rewarding." Several near-peer mentors discussed how important they felt it was to have the freedom and opportunity to develop mini-projects in their areas of interest. One stated, "I really enjoyed the ability to work without constraints and teach what I love."

One respondent stated that teaching "has greatly increased my confidence of speaking in front of people, and it has helped me develop a better way of explaining and thinking about topics." Another 45 comments echoed this mentor's observation that teaching "brought me out quite a bit, forced me to develop my writing and study skills." The interlacing of teaching experience with confidence and communication further extended to practicing laboratory skills. One near-peer mentor stated that his participation in GEMS "has helped me become more confident in laboratory skills, especially the ones that I taught multiple times."

Perceptions of Near-Peer Mentorship

This theme included the mentors' reflections on the benefits and challenges of their experiences in terms of their relationships with others. Respondents wrote about the benefits of working with other near-peer mentors on 22 occasions. Overall, they appreciated the support they received from one another, the specific tips that were offered, and the way they learned from the examples of others. Seeing another mentor as a model, one wrote, "I admired her consistency. I think that is a very underappreciated trait that simply needs to be better emphasized. So she inspired me to be more consistent, dependable, and adaptable." The mentors mentioned incorporating teaching strategies they had observed, such as using real life examples. Another mentor reported a growing camaraderie:

> I had a great relationship with the other mentors. It's always a group struggle and a group effort to get everything done and done well. We talk over lunch, hang out outside of work, and talk about each other's pasts and futures.

One of the most frequently mentioned advantages reported by the mentors (21 comments) was working with GEMS students. One mentor described the experience of contributing to student learning by saying, "The feeling of a child finally getting a concept after failed attempts is really awesome. The light bulb finally turns on followed by a jubilant 'OOOHHH' brings a smile to our faces every time." They wrote of their excitement in "seeing the student grow throughout the week" and that when "students are able to informally ask questions about college life, I could see many of them suddenly excited and motivated." Another mentor shared this experience:

> One instance that stood out to me was when one advanced student asked for my help on an outside project. I got to work with him one-on-one during breaks or at the end of the day, and it really made an impact on me to see that he was understanding what I was teaching and that he could use the knowledge I gave him outside of GEMS.

The near-peer mentors discussed learning from their students eight times. One described it as "I feel that I impacted someone at the beginning level that was an aspiring microbiologist. I gave her some equipment to pursue her passion. But it also inspired me to work harder."

Comments on challenges centered on navigating a working relationship with one another. Respondents reflected on this idea 12 times. One mentor discussed some difficult dynamics with other near-peer mentors, saying, "What I didn't like was being underestimated, being taken advantage of a bit by my peers, and maybe the way certain modules were undertaken." Another wrote about shifting dynamics throughout the summer by stating, "Other near-peer mentors do their own thing. In my opinion, the dynamics between near peers worsened as the GEMS program progressed because there was a lack of support between the mentors." A mentor reflected on what needed to be done when some co-workers were not upholding their responsibilities and wrote, "I learned that, although this is a professional setting, coworkers might need a reminder to clean up after themselves and to keep up with their regular duties." One mentor decided that learning to work with more challenging co-workers was part of a professional experience and commented, "I've learned to deal with difficult co-worker relations. Obviously you are not always going to be best friends with your co-workers, so learning to work through differences in opinions has been a vital lesson."

GEMS Students

The responses of 59 advanced GEMS students who completed the open response prompt (the best part of having near-peer mentors was …, because….) were divided into two categories, namely *rapport* and *guidance*. *Rapport* described the relationship that developed between the students and near-peer mentors, and it was mentioned on 45 occasions. The advanced GEMS students frequently talked about being able to connect to near-peer mentors in a way that they could not with teachers or older mentors. Examples of student responses included "you feel comfortable around them, you can relate, and you can ask them for guidance," "it's easier to communicate with them than it is with an older mentor," and "the ability to talk to someone older but who's not SO much older as to not [be able] to have relevant discussions [with] me." The GEMS students also expressed the ways in which they perceived the mentors. One student commented, "They are smart and funny." Another said, "They were really cool and fun to learn from. They're all super amazing and easy to talk to."

The idea of mentors being guides for learning was mentioned 20 times in the survey responses. One student described the teaching style of near-peer mentors: "Although they were rigorous in the material, they made it fun." Another student explained, "They taught us in a way that was very understandable because they had just recently learned the subject matter themselves." Examples from other students included, "They were able to explain [things] to me better than a normal teacher would since they were closer to my age," "They make things extremely easy to understand, and they know how to get through to/or appeal to teenagers more," and "They were young enough to relate to, and they knew how to teach kids our age."

Discussion

Our study examined a novel near-peer mentoring model using qualitative research methods to explore the perspectives of near-peer mentors (undergraduates and post-baccalaureates) and student (grades 6-12) mentees during a summer science education internship. Our findings offer three contributions to the literature on mentoring. First, the near-peer mentorship model offers personal, educational, and professional benefits for near-peer mentors and increases the

interest and engagement of high school students studying the STEM disciplines. This suggests that it is a valid model and has the potential to offer support to young scientists on a broader scale. Secondly, this model is effective in reinforcing the pipeline of scientific learning by providing a continuum of learning opportunities for future STEM professionals as it bridges the gap between pre-college internships and undergraduate internships for those beginning their professional career. Finally, this study supports past findings that internship experiences foster professional skills and confidence in developing scientists.

The findings of this study suggest that the near-peer mentorship model is an effective approach to science education and mentorship. Participants reported that they appreciated the unique aspects of the combined approach, and they expressed interest in continued participation in both STEM and STEM education. Given these positive results, the near-peer mentorship model may have potential to expand beyond the WRAIR program and to impact a broader scale of scientific learners.

The participants frequently discussed being able to do something (e.g., develop a module, teach a large group of students, or make an impact on young scientists) that they never thought they would be able to do at the start of their internship. They commented on how this increased awareness of their own potential and gave them the confidence to explore educational and career options of interest to them that they might not have otherwise considered. While all near-peers reported a continued and increased interest in pursuing STEM careers following their participation in this summer internship, it is telling that gains in professionalism and confidence in general resonated so strongly with them. Assuming the role of STEM instructor reinforced their commitment to STEM as a field of study. This finding suggests that the near-peer mentor model can help provide undergraduates with the professionalism and self-efficacy that is essential to continuing their pursuit of their educational and career goals.

A crucial advantage of this model is that it provides a continuum of training for those interested in pursuing STEM education and careers. This model offers the opportunity for middle and high school students interested in science to explore their interests while also providing college and post-baccalaureate scientists the chance to advance their skills and further their training. This continuum of learning fosters the development of young scientists and engineers, keeping them within the field at a time when STEM professionals are in high demand (National Research Council, 2012). In addition, it provides an introduction to STEM education when there is a shortage of STEM teachers in K-12 schools (Tobias & Baffert, 2012). While science and engineering jobs are increasingly being sent overseas, the near-peer mentorship model encourages students of various ages to remain within the STEM pipeline, develop their expertise, and pursue careers in science and technology during a time when there are employment opportunities (National Research Council, 2012). Upon completing the internship, many near-peer mentors have gained the requisite skills to qualify for work at other research facilities (Feldon, et al., 2011).

Career advancement is a key outgrowth of the near-peer mentors' participation in the program. They reported being able to gain experiences in a professional environment, develop important professional skills, cultivate their professional interests, and advance their scientific careers. In general, near-peer mentors felt that their role had prepared them in a way that made them more desirable candidates for higher education and STEM related careers. They also recognized the professional connections that were cultivated during the summer internship. In addition to recommendation letters from the WRAIR, the mentors had made connections with potential employers, links to research labs at their respective universities, and like-minded colleagues and mentors. Follow-up data from the near-peer mentors who participated in the GEMS program in the summer of 2012 revealed that all who sought continued education or employment in STEM fields were able to secure their desired positions.

One of the primary goals of the near-peer mentor model is to provide scientific learners at different levels with the opportunity to continue their training and pursue their interests. Findings from this study suggest that the near-peer mentor model through the WRAIR GEMS program has been successful in achieving the goal of keeping students within the pipeline of STEM.

Limitations and Future Research

Limitations of this study include the inability to generalize results to a broader population as the sample included near-peer mentors and students from only one GEMS site. Additionally, this research only provided a snapshot of the near-peer mentor experience; and little is known about the long-term professional and educational trajectories of these participants.

With regard to future directions for research, we recommend examination of this model at other Army research sites. It would also be of interest to determine if the near-peer mentorship model can be effectively incorporated into more established scientific training programs such as undergraduate research assistantships. Many young scientists serve as undergraduate research assistants during their academic careers (Thurgood, Ordowich, & Brown, 2010), and incorporating novel models of mentorship and training like near-peer mentorship has the potential to afford significant educational, professional, and personal benefits for participants.

A final recommendation involves examining the long-term outcomes associated with near-peer mentor participation in the GEMS summer internship. It would be interesting to learn about how their participation influenced near-peers over time with regard to continued education, professional goals, and personal growth.

Conclusions

Overall, our findings suggest that the near-peer mentorship model helps to prepare early career scientists for their futures while giving them the opportunity to do the same for younger students. The model has potential to expand to broader settings in order to provide more young scientists with a STEM internship.

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